PHYTOTOXICOLOGY SECTION ASSESSMENT SURVEY INVESTIGATIONS IN THE VICINITY OF CANADIAN INDUSTRIES LIMITED, COURTRIGHT, ONTARIO DURING 1986 AND 1987

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INTRODUCTION:

The Phytotoxicology Section of the Air Resources Branch has conducted vegetation assessment surveys in the vicinity of Canadian Industries Limited's Lambton Works since the early 1970's. The manufacture of superphosphate fertilizer and the subsequent storage of production wastes in lagoons east of the plant have resulted in substantial emissions of hydrogen fluoride (HF) to the atmosphere. As a consequence, injury to vegetation has been observed and documented by staff of this Section in every year since 1972. A number of terrestrial plant species found in the Courtright area, including several maple species, are considered sensitive to airborne HF. A further concern in the area near CIL has been and is, fluoride uptake by forage species and subsequent ingestion of the contaminated forage by livestock.

Coincident with the surveys around CIL, Phytotoxicology staff examined sulphur dioxide sensitive vegetation at a number of sites around the nearby Lambton Generating Station, a coal-fired electric power generating station owned and operated by Ontario Hydro. Fossil-fueled power generating stations are major sources of sulphur dioxide and nitrogen oxides. In addition to the Ontario Hydro plant, Detroit Edison's coal-fired St. Clair Generating station is located due west of the CIL works on the Michigan side of the St. Clair River.

In view of the proximity of these sources and the use of sample analysis results common to both the fluoride and sulphur dioxide impact surveys, previous years' Phytotoxicology results for the Courtright area have been consolidated into one report. Commencing with the 1986 reports, separate reports will be prepared for each source. The results for those surveys conducted around the CIL plant in 1986 and 1987 are reported here.

SURVEY DESIGN:

In 1986 and 1987, vegetation assessment surveys around CIL were conducted in a similar fashion to those surveys in the preceding three years. At each of the nine sites shown in Figure 1, various indigenous vegetation species were examined for hydrogen fluoride injury. Concomitant with these visual examinations, duplicate samples of grasses and silver maple (Acer saccharinum) foliage were collected at each site. At ten other sites, all in close proximity to the CIL works (Figure 2), duplicate samples of grasses only were collected. In 1986, as in previous years, the intensive forage sampling close to CIL was conducted on a monthly basis. In more recent years this level of sampling has been considered unnecessary. A single August sampling was judged adequate to form a reasonable assessment of fluoride contamination close to CIL. Half of the 10 sites are located on company property.

All samples were collected into new, clean plastic sample bags for delivery to the Phytotoxicology Section vegetation processing laboratory in Toronto. One-half of each maple sample was washed for 30 seconds in an aqueous solution 0.05% in Alconox detergent and 0.05% in EDTA, followed by three 10 second rinses in distilled water. All samples were then dried in paper bags, ground to a coarse powder in a Wiley mill and submitted in glass jars to the Laboratory Services Branch, Ministry of the Environment for total fluoride analysis.

OBSERVATIONS AND RESULTS:

(a) Injury Observations

As in all previous years in which this survey has been conducted, fluoride induced foliar injury was observed on sensitive plant species at Sites 1, 11 and along Sombra Concession Road 4/5, in the area south of the CIL lagoons. Injury was noted on silver maple, plum (cultivated varieties growing near where farm houses once

existed) and choke cherry. In all cases the injury was considered to have been trace to light in degree; i.e. less than 10% of the leaf area observed was affected.

(b) Unwashed Silver Maple Analysis

The results of analysis of unwashed silver maple foliage are presented in Table 1 below.

TABLE 1: RESULTS of ANALYSIS of UNWASHED SILVER FOLIAGE collected in the vicinity of the CIL LAMBTON WORKS, COURTRIGHT

Sampling Site Number	Fluoride Concentrations in Unwashed Maple Foliage, by year in parts per million, dry weight				
	1983	1984	1985	1986	1987
1	337	668	464	435	670
2	14	14	11	16	11
3	17	12	14	12	15
6	29	53	42	56	57
7	19	15	9	16	12
8	16	14	7	11	9
11	84	101	160	165	330
12	19	21	12	16	15
13	13	12	8	12	7
Three Site (Nos. 1, 6, & 11) Mean	150	274	222	219	352
ULN for Fluoride*	15	15	15	15	15

* see Appendix 1

Fluoride concentrations in maple foliage exceeded the Phytotoxicology **Upper Limit of Normal** (ULN) value in unwashed rural vegetation, at all sites within 1 km of the CIL Lambton Works, in all years for which data are shown. The derivation of ULN's for

contamination of vegetation is described in Appendix 1. Results from those stations located approximately 2 km from the fertilizer plant were close to but not significantly higher than the ULN value.

It is normal, even around a source that is very consistent in its emissions, that the measured pollutant concentrations in terrestrial plant receptors near that source will vary somewhat from year to year. Differences in wind velocities, precipitation, hours of full sunlight can influence the rate of uptake and/or retention of the contaminant. Rough contaminant comparisons between years can, however, be made by comparing the mean results for several sampling sites near the source. When this is done using fluoride data in Table 1 it is evident that exposure of vegetation near the source to airborne fluoride was slightly higher in 1987 than in the other five years. This was due mainly to a substantial increase at Site 11. The 1986 mean was similar to the other three years' means.

(c) Washed Silver Maple Analysis

Vegetation foliage that has been collected for contaminant analysis is often washed to remove that fraction of the contaminant which has been deposited in particulate form. This practice is commonplace where fluorides are the source of concern since the normal fluoride content of soil in Ontario averages between 200 and 600 parts per million (ppm). Re-entrainment of soil particles could lead to significant upward distortion of the analytical results. Also, internal foliar contamination is normally considered more relevant from an injury perspective.

The results of analysis of those portions of the maple samples collected during the course of vegetation surveys 1983 to 1987 are presented in Table 2 below. It is evident by comparing the results in Tables 1 and 2 that very little surficial fluoride contamination was present in the samples from any year. In some cases the "unwashed" results are lower than the washed results, suggesting that the differences represent the sampling variability and laboratory error.

TABLE 2: RESULTS of ANALYSIS of WASHED SILVER FOLIAGE collected in the vicinity of the CIL LAMBTON WORKS, COURTRIGHT

Sampling Site Number	Fluoride Concentrations in Washed Maple Foliage, by year in parts per million, dry weight				
	1983	1984	1985	1986	1987
1	293	550	448	440	630
2	10	12	9	12	12
3	13	11	10	11	17
6	19	43	29	49	40
7	12	13	8	9	9
8	10	12	5	9	8
11	55	96	97	140	315
12	12	15	9	13	12
13	7	11	6	8	8
Three Site (Nos. 1, 6, & 11) Mean	122	230	191	210	328

(d) Forage Analysis

The ten forage collection sites shown in Figure 2 provide good measures of the degree of fluoride contamination present in forage near the company. Since there have been a few instances during the past fifteen years when cattle have been grazed near the CIL works, particularly to the east, there has been concern over possible fluorosis, a fluoride induced disorder of cattle affecting the teeth and bones.

The results of analysis of grasses collected at the ten sites in 1986 are presented in Table 3 below. In 1987 the forage collection was conducted on one occasion only, in mid-August, coincident with the main survey. These results are shown in Table 4, in which are included also, the comparable results from the August forage collections during the years 1983 to 1987.

TABLE 3: RESULTS of ANALYSIS of UNWASHED GRASSES collected at 10 sites in the close vicinity of the CIL LAMBTON WORKS, COURTRIGHT in 1986

Sampling Site Number	Fluoride Concentrations in Unwashed Grasses, by year in parts per million, dry weight					
	May 15	June 11	July 17	Aug. 20	Sept. 17	Oct. 15
1	50	16	13	6	8	6
2	95	130	192	445	90	23
3	26	162	147	80	170	39
4	9	47	20	31	29	20
5	4	4	8	8	35	11
6	6	10	12	36	25	14
7	33	77	69	105	130	36
8	49	128	40	95	61	8
9	75	68	30	88	39	25
10	15	20	8	17	14	10
Phytotox. ULN for F in grasses	12	12	12	12	12	12
Regulated Limits for Fluoride in Forage	35 a 60 b 80 c	35 60 80	35 60 80	35 60 80	35 68 80	35 60 80

a growing season average
b average for any 2 consecutive months
c average for any 1 month

TABLE 4: RESULTS of ANALYSIS of UNWASHED GRASSES collected at 10 sites in the close vicinity of the CIL LAMBTON WORKS, COURTRIGHT Mid-August, 1983 to 1987

Sampling Site Number	Fluoride Concentrations in Unwashed Grasses, August Collection, by year in parts per million, dry weight				
	1983	1984	1985	1986	1987
1	11	21	8	6	14
2	137	407	196	445	82
3	23	48	76	80	89
4	8	52	22	31	36
5	7	23	33	8	16
6	11	46	29	36	24
7	24	151	127	105	36
8	40	189	104	95	27
9	8	85	63	88	23
10	3	21	29	17	9
All Site Mean	27	104	69	91	36
Phytotox. ULN for F in grasses	12	12	12	12	12
Regulated Limit for Fluoride in Forage	35 a 60 b 80 c	35 60 80	35 60 80	35 60 80	35 60 80

a growing season average
b average for any 2 consecutive months
c average for any 1 month

The various benchmark values for evaluating the significance of fluoride concentrations in forage are shown in Table 3 and 4. The first, the Upper Limit of Normal for grasses collected in a rural area is relatively low. This value is exceeded at most sites, on most sampling dates.

The other benchmarks are the recommended limits for fluoride in forage for three time-averaging periods. The higher levels have been set to protect cattle from fluorosis. These limits were exceeded frequently in all years in which these surveys have been conducted. Consequently, forage in most of the area represented by this sampling program, must be considered unfit for consumption by livestock. Since much of the land in this area is owned by CIL, the company has agreed that their land will not be leased to local farmers for pasture or fodder harvest. The planting/harvest of cereals, soybean and corn, for grain harvest only, is considered acceptable.

Of additional note are the results from forage sampling sites 5 and 6. Cattle have been observed grazing on the land east of these sites, specifically in those fields immediately east of Highway 40 and north of Sombra Concession 4/5. Results from these sites have been among the lowest found. Consequently forage in the area east of Highway 40 is considered fit for livestock consumption.

SUMMARY:

Vegetation assessment surveys were carried out in the vicinity of the Canadian Industries Limited Lambton Works in 1986 and 1987. The survey design in each year was generally the same as that of the previous fourteen years in which the surveys have been conducted.

Injury to sensitive vegetation was observed in two areas, one north, the other south of CIL, in both years. The injury was considered to have been trace to light in severity.

Fluoride concentrations in unwashed silver maple foliage, collected at three sites within 1 km of CIL exceeded the Phytotoxicology Upper Limit of Normal concentration in both years, as they have in all years to date.

Washed silver maple foliage was found to contain very similar concentrations to the unwashed foliage, indicating that the foliage has not been significantly contaminated by fluoride bearing particulate, either from CIL or from road/soil dust.

Forage (grasses) samples collected at ten sites in the immediate vicinity of the CIL works contained concentrations of fluoride substantially higher than the Phytotoxicology Upper Limit of Normal for rural forage. Many of the results also exceeded the various limits for fluoride in forage, designed to protect cattle from fluorosis.

On the balance, fluoride concentrations in terrestrial vegetation, collected around the CIL Lambton Works did not change significantly in 1986 or 1987 compared to previous years. While the fluoride content in silver maple foliage samples collected within 1 km of CIL increased in 1987, over earlier years, fluoride in forage was somewhat lower, compared to previous years' results.

Canadian Industries Limited is presently developing a decommissioning plan for the gypsum storage ponds which will include the "capping" or "sealing" of the ponds with clay and topsoil. This is expected to eliminate fluoride emissions from this source.

APPENDIX I

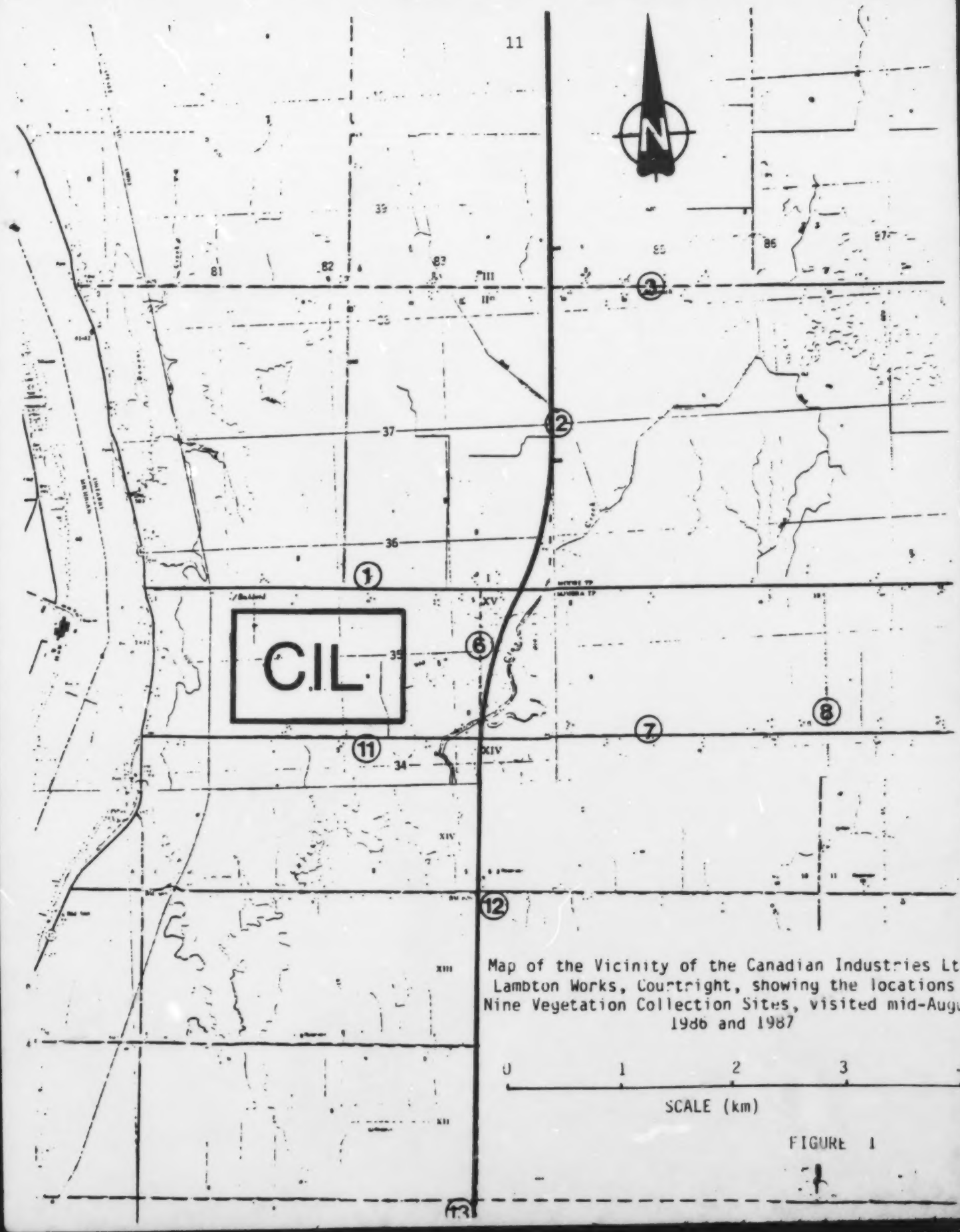
Derivation and Significance of MOE "Upper Limits of Normal" Contaminant Guidelines

The MOE "upper limits of normal" contaminant guidelines essentially represent the expected maximum concentration of contaminants in surface soil (non-agricultural), foliage (tree and shrub), grass, moss bags and or snow from areas of Ontario not subject to the influence of point sources of emissions. "Urban" guidelines are based upon samples collected from centers of minimum 10,000 population. "Rural" guidelines are based upon samples collected from non-built-up areas. Samples were collected by MOE personnel using standard sampling techniques (ref: Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch: Technical Support Sections - NE and NW Regions). Chemical analyses were performed by the MOE Laboratory Services Branch.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distributions that are "normal", 99% of all contaminant levels in samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are non-normal, the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless they lie within the observed upper range of MOE results for Ontario samples.

Due to the large variability in element concentrations which may be present across Ontario, even in background data, control samples should always be collected. This is particularly important for soils, which may show large regional variations in element composition due to difference in parent material. Species of vegetation which naturally accumulate high levels of an element also may be encountered.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are below the guidelines are not known to be toxic.

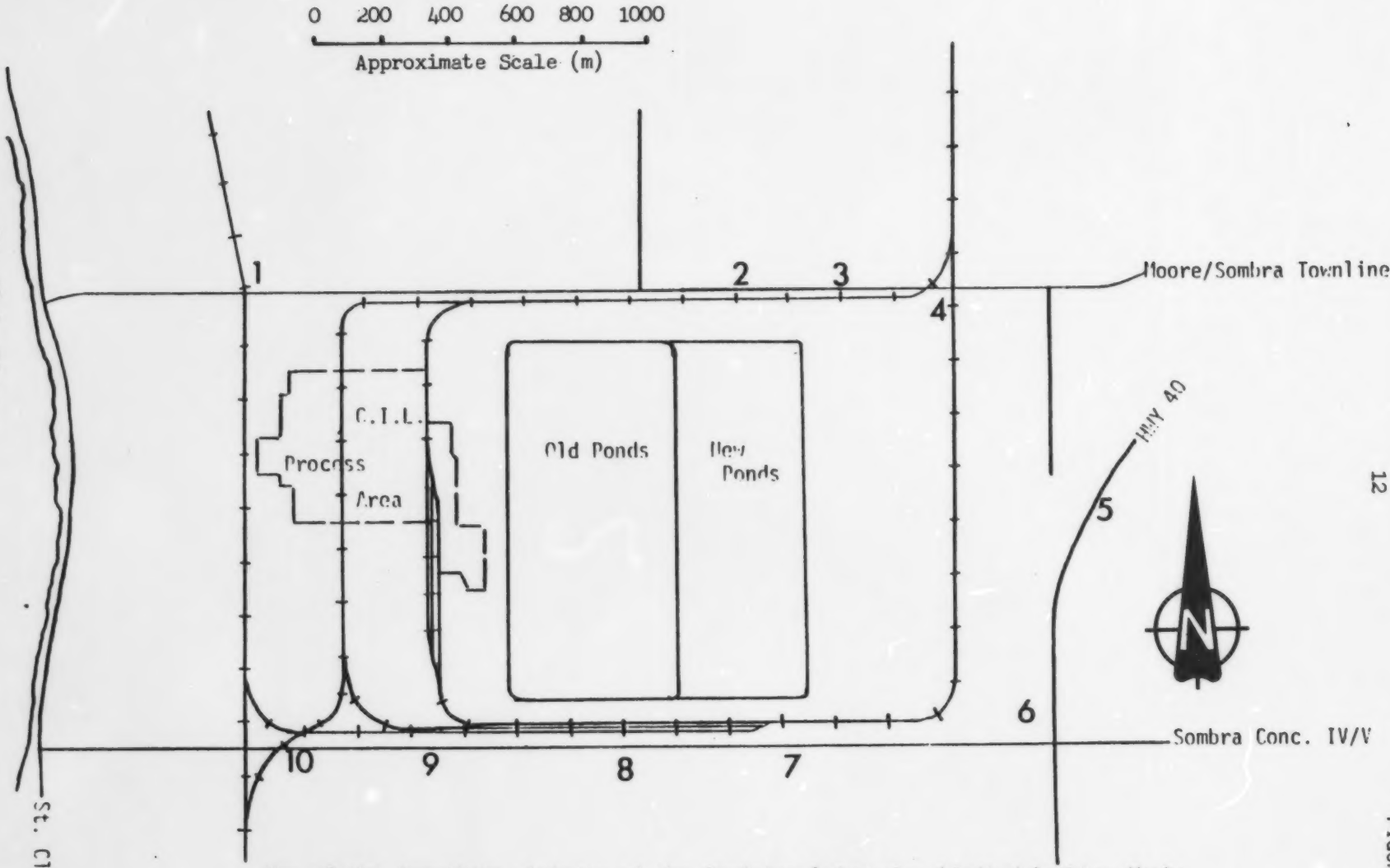


Map of the Vicinity of the Canadian Industries Ltd Lambton Works, Courtright, showing the locations Nine Vegetation Collection Sites, visited mid-Augu 1986 and 1987

0 1 2 3 4

SCALE (km)

FIGURE 1



Map of the immediate vicinity of the Cnadaian Industries Limited Lambton Works showing the locations of ten sites at which grasses were collected on six dates in 1986 and mid-August only in 1987.

FIGURE 2